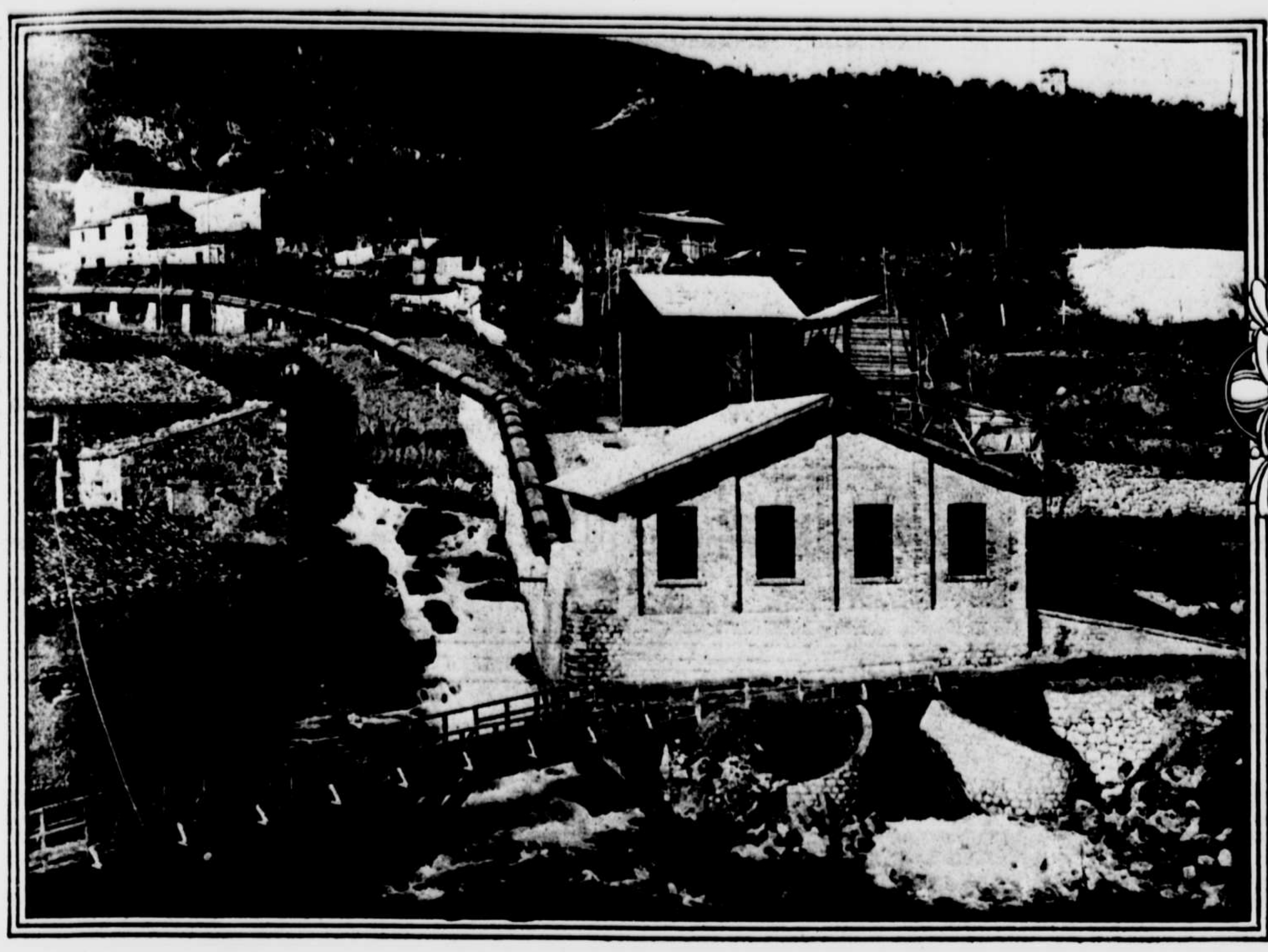
GREAT WATER SYSTEM JUST COMPLETED BY ITALY



One of the power stations where electricity is generated for industrial purposes.

Entrance to one of the tunnels through the Apennines at Santa Maria dei Santi.

"Dryest Apulia" Reclaimed by a Wonderful System of Canals Leading From a Natural Mountain Reservoir 137 Miles Away

A FEW days ago a brief item, unnoticed in the more spectacular flow of war news, announced the formal accomplishment of an undertaking which in point of numbers benefited is one of the greatest of its kind.

Quietly, without the clangor of trumpets, modern Italy has achieved another big feat of her luminous destiny and her victory over a thousand-year-old foe is being celebrated by her sons who had devoted to that struggle the best of their intelligence and activity. As the magic wand of an almighty rhabdomancer had they acted over the soil of Apulia, for hundreds of centuries deprived of that most essential element of life, water; a magnificent stream of water, captured hundreds of miles away, was given to its inhabitants, as a blessed relief to their age old condition of drought and an incentive to a wonderful improvement of their agricultural resources and of their industry.

Apulia represents the most important part of the southeast of Italy. Covering an area equal to one-fourteenth of the whole kingdom, bathing her extended coasts on the Adriatic, "the sea of the renewed fortunes of Italy," her numerous ports being headquarters for the Italian trade with the Orient, Apulia constitutes a big factor in the economy of the whole nation.

Nature, who was so generous with her sister regions, showed herself very parsimonious with her. Since the most remote antiquity Apulia had been known for the scarcity of her water supply. "Siticulosa Apulia," she was called by Horace, and this description was not an exaggeration of the truest and most bitter reality. Her supply of drinking water, except in a very few sections of the province of Bari, was almost exclusively dependent on rain water, which was preciously collected and frugally conserved. In exceptionally hot seasons the cisterns invariably became empty, and the Government was then compelled to send drinking water for the relief of the population by means of tank ships to the towns on the coasts and in tank wagons to the interior.

The reason for this almost total absence of natural springs must be looked for in the geological formation of the soil, consisting mostly of a low plain of tertiary cretaceous formation, broken at rare intervals by low hills but absolutely devoid of function of absorbing and storing the mountains, which, by reason of their atmospheric moisture, constitute what might be called the lungs of the earth.

Other regions in the nearby provinces were in a more favorable situation, but they were separated from Apulia by the Apennines, the backbone of Italy, and this mountain range was an insuperable barrier to the conveying of their water to Apulia, even for the Romans, the greatest and most audacious hydraulic engineers of early times.

It was then quite natural that not before the feasibility of boring extensive tunnels through the mountains was demonstrated could any serious attempt be made to solve the problem, a problem which involved also the task of feeding 2,200,000 people, not grouped in any one centre but distributed in 260 towns covering an area of 8,000 square miles.

The first effective plan for this biggest of all water works dates back to 1868, nearly coinciding with the completion of the first long distance tunnel through the Alps. So accurate and complete was this early plan that except for the few variations suggested during the progress of the work, more by the desire of extending its benefits to more people and localities than by some unforeseen difficulties, it differs very little in its general lines from what actually was done half a century later.

On the other side of the Apennines, west of Apulia, a region exists exceptionally favored with a natural water supply. This region, belonging to the provinces of Avellino and Benevento and approximately covering a triangular area whose apexes can be represented by the towns of Avellino, Campagna and Benevento, is characterized by the presence of a group of high mountains, the summits of which are snow covered a greater part of the year and presenting, besides, an unusually large number of natural basins in which rain water collects.

Being composed of rocks of a most porous nature these mountains represent an important factor in the absorption of water and atmospheric moisture. Instead of being allowed to travel enormous distances before reappearing in form of springs, as usually happens, the water is stored in the zone in which it collects.

An extended belt of impermeable clay isolates the group of mountains referred to from the plateau above which it towers and forms in the interior of the earth an immense natural reservoir from which the excess of water is allowed to escape only at the lower points of its edges. These lower points being located in a very restricted area the springs are closely grouped. The area covered by the porous rocks covers about 233 square miles between Caposele, the right bank of the River Sele, Campagna, Salerno and Avellino. The total volume of water issuing from these springs is never less than 6,000 gallons per second.

These conditions were revealed by a series of geological surveys and accurate measurements of the volumes of water annually precipitated and the output of the springs. This survey led also to an important discovery: that the water required about six months for its voyage through the underground canals, and that the springs reach their maximum output half a year after the period of the heaviest rainfalls. Consequently there is no fear of a shortage of water in the aqueduct during the hotter months of the year.

Of the springs referred above, the most important, from the standpoint of their utilization for the aqueduct of Apulia, were those emanating from the eastern slope of Mount Paflagone, near the small town of Caposele. The principal group of them issues from a large limestone wall, at points having an altitude of 1,380 to 1,389 feet above sea level and embracing an arc the concavity of which faces the east. The water, after having collected in a natural basin, is precipitated from a height of about ninety feet to give origin to the River Sele.

Providentially nature had insured this basin against any waste due to filtration of the water collected therein by a substratum of impermeable clay, so that nothing further was necessary in order to retain the water and lead it to the aqueduct but to close the passage through which it previously escaped.

This was done by constructing a retaining wall 6¾ feet thick across this passage. The wall has its foundations in the clay, is almost entirely embedded in the ground and has its top 8¼ feet above the mean level of the water in the collecting basin.

The water emanating from the rock is collected by twelve small canals, each 2¾ feet wide, adjoining the rock at the points where the springs appear more abundantly. These canals have a natural soil bottom and perforated walls formed by concrete bricks of two foot side, with an opening of six inches between them. They lead into a connecting canal 180 feet long, with a width increasing from 10 feet to 16½ feet, having also a natural soil bottom, at a maximum of 1,375 feet over sea level. The walls of this canal are built of piles, bound together by arches of masonry, the spaces being filled in with brick.

The spaces between the walls of the small canals, the adjacent side of the main one and the rock opposite, as well as the spaces on the other side of the main canal, are filled in with a bed of gravel through which the water, coming from the soil, filters and overflows through the perforated walls into the collecting canals. The main collecting canal is covered with a reenforced concrete floor and the small canals with cement slabs. All the collecting zone from the rock to the retaining wall is covered with a bed of arable soil 2¾ feet deep, protected against percolation of rain water by a perfect system of drainage.

The collecting canal above described branches into a supply canal of masonry 56 feet long and 16½ feet to 13 feet wide. When the water in this supply canal reaches a level of 3 feet 3 11-32 inches a volume exceeding 1,585 gallons per second can be delivered, which is the maximum quantity for which the whole work was designed.

This canal is provided with a device enabling the water to be eventually directed into an auxiliary discharging canal leading to the main one and thence to the old bed of the River Sele.

The supply canal leads into a collecting well 23 feet long, 13 feet wide, the bottom of which is 1,365 feet above sea level: the wall opposite the spot where the water arrives is provided with sluice gates for regulating the inlet of the water to the aqueduct or discharging the entire volume through a chamber 16½ feet long, 10 feet broad, into the main discharging canal 242 feet long, which leads to the old bed of the River Sele.

The lower wall of the connecting wall contains the weir (1,372 feet above sea level), over which the water falls into a chamber the edge of which constitutes the starting point of the aqueduct.

The main canal of the aqueduct runs from Caposele to Fasano over a length of 132.67 miles, of which 60.2 miles are tunnelled, 5.28 are canal bridges and 4.59 are siphons. The first 1,095 feet, extending from Caposele to the Tredogze torrent, are regulated in order to ascertain the volume of water passing through.

The main canal may be considered as composed of six sections, each dimensioned for an output varying from 1,585 to 528 gallons per second.

Engineering Triumphs of the Aqueduct Builders of Ancient Rome Far Surpassed by Their Modern Descendants

The supply of water from the main canal to the 260 towns in the three provinces of Apulia and in the adjacent province of Potenza is secured as follows:

For the Province of Foggia the water is taken by a branch canal extending over 28.55 miles, of which 2.16 miles are tunnelled, 8.4 miles are siphons and 3.44 miles are canal bridge. One hundred and twenty-nine miles of branches run from it to the towns. There are 17 reservoirs of a total capacity of 13,448,000 gallons, 9 pumping stations for supplying the centres on a higher level than the canal and 5 power stations of 1,087 horse-power total output. An interesting feature is the great siphon of Ofanto, having a length of 3.64 miles, a normal output of 290 gallons per second and a drop of 102 feet.

For the province of Bari and a few towns in the province of Potenza the supply is assured by 535 miles of canals and piping. There are fifty-three reservoirs with a total capacity of 27,212,500 gallons, eight pumping stations and eleven power stations with a total output of 3,621 horse-power.

The supply for the province of Lecce is taken by a branch canal parting from Fasano and extending over 18.95 miles, of which 4.11 miles are tunnelled. Four hundred and forty miles of canals lead to the towns and 220 miles will be piping in the towns themselves. There will be seventy-seven reservoirs with a total capacity of 35,138,500 gallons.

For the supervision of the main canal more than 100 miles of special roads have been built, connecting with the national and provincial ones. About every four miles of canal there is a watchman's house. All buildings are connected by an up to date telephone system.

It has occurred often, in the preceding brief description of the whole arrangement, to mention power and pump stations. Of the former, producing energy by the difference of level where it could be utilized, there are a total number of eighteen ranging from 30 to 2,500 b. h. p. output. As the total output of the power stations is 8,685 b. h. p. and the total amount required by the pump stations will be 1,267 b. h. p. there are still available 7,418 b. h. p. which can be advantageously supplied to the small industries or to the farms scattered all over the regions.

The supply of 26.42 gallons per capita per diem to a population of 2,200,000 people would scarcely utilize one-third to two-fifths of the whole output. The rest will be devoted to irrigation purposes and this will be one of the greatest advantages of this undertaking which will bring so wonderful an improvement to that region of Italy.

The turning of the water into the main canal, which took place officially on April 16, celebrated the successful accomplishment of this undertaking, which has required more than ten years actual work and an expenditure of more than $35,000,000.

A few details still remain to be completed and some towns in the province of Lecce, the most distant from the end of the main canal, will not have their supply before the end of next year.

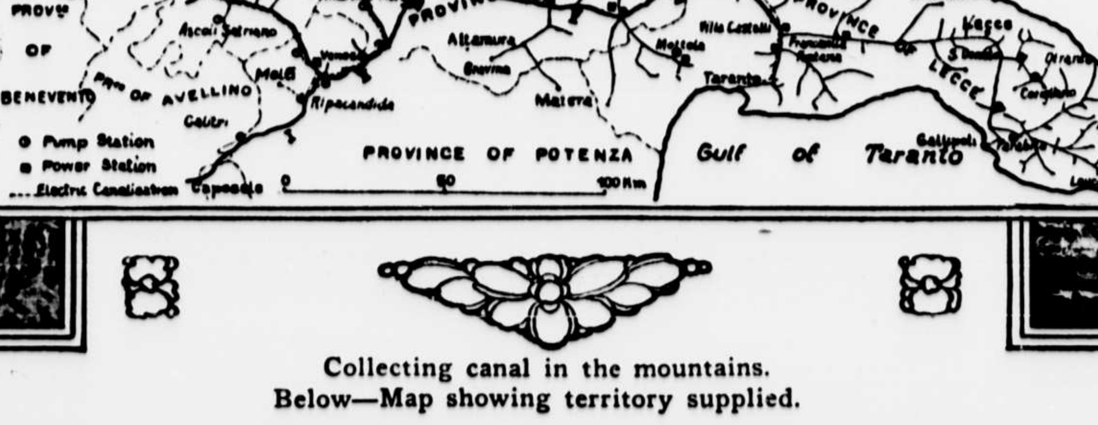
The great advance in hydraulic engineering is well illustrated by a brief comparison between the construction of the great Roman aqueducts of antiquity and this most recent triumph of Italian engineers. The massive Roman aqueducts, impressive sections of which still remain and are familiar to all who have travelled in Italy either in the flesh or pictorially, in the spirit, scorned apparently all barriers of nature. As a matter of fact, however, the Romans found less difficulty in constructing those remarkable arches of masonry across valleys, often in a double tier and rising to heights exceeding 100 feet, than they did in underground work.

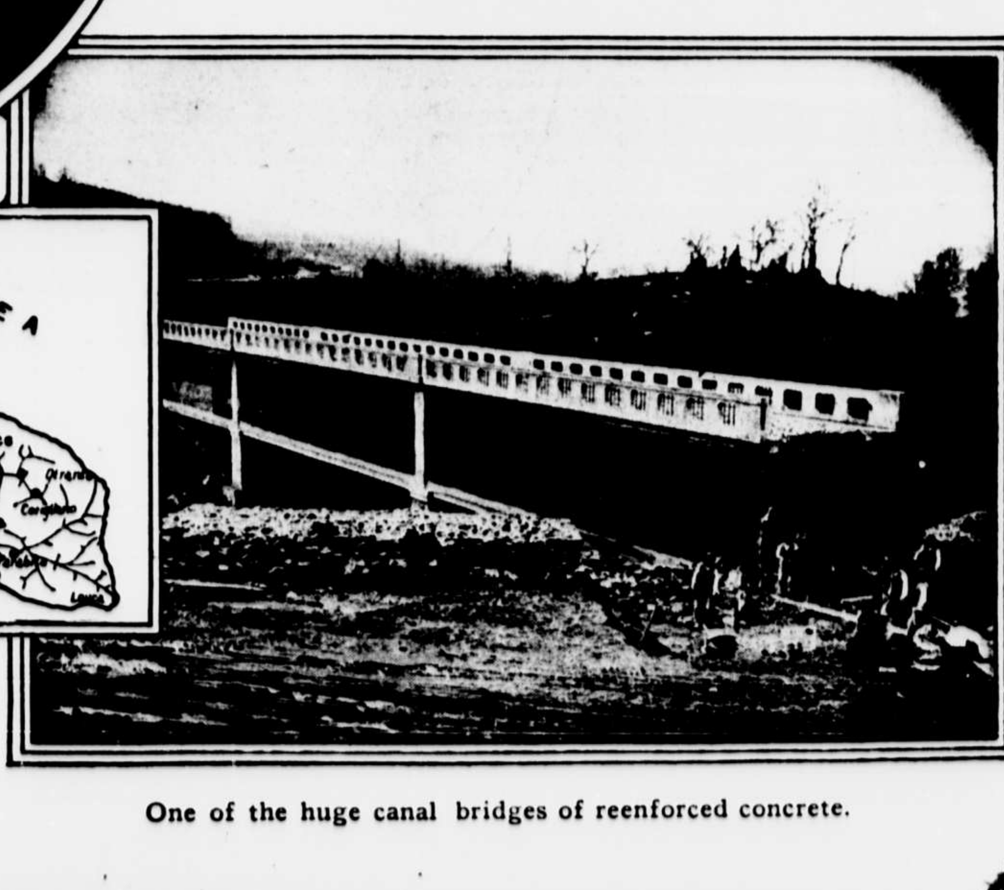
In the latter form of construction they were limited to open cutting and short distance tunnelling. Extensive tunnelling, such as piercing the Alps at St. Gothard or the Simplon, was impossible until compressed air, modern drilling machinery and dynamite came into usage.

It must be recalled also that the ancient Romans were without surveying instruments, except the crudest, depending upon the simplest calculations in triangulation, and that the lens, and therefore the transit, was unknown.

For these reasons, while the ancient Roman works that brought cool, pure spring waters into the capital of the world for the delectation of its patrician populace appear to defy nature, it will often be noted that they have been turned miles out of a straight line to avoid some natural obstacle that an engineer of to-day would laugh at. And in the avoidance of such obstacles it often happened that the Roman engineers would bridge a chasm with a soaring structure of massive masonry that would spell bankruptcy for a modern contractor.

The great modern triumph of Italy differs from these ancient marvels of construction chiefly in this respect: Where the old Romans avoided minor obstacles, the modern Latins have gone straight through great ones. Therein lies the whole story of the advance scored by modern engineering.





Carrying the canal across a ravine by bridge.

Collecting canal in the mountains.
Below—Map showing territory supplied.

One of the huge canal bridges of reenforced concrete.